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NO. 3: THE SCLEROTIC RING IN THE HADROSAURIDAE

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THE SCLEROTIC RING IN THE HADROSAURIDAE

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INTRODUCTION

Sclerotic ossifications or chondrifications are known in a great variety of vertebrates, exclusive of mammals and modern amphibians (Edinger, 1929). Those of birds have been most systematically studied, notably by Lemmrich (1931). This author established the fact that the sclerotic ring in birds consists of 11 to 16 plates, which are scale-like, and more or less overlapping. The overlap is not continuous in one direction; there is one plate, or more, which overlaps at both ends (plus-plate), and one, or more, which is doubly overlapped (minus-plate). Where only one of each of these plates is present the ring is divided into two halves, more or less anterior and posterior, respectively, and not usually symmetrical. The minus-plate lies near the top and the plus-plate near the bottom. In the second case, where two plus- and minus-plates are present, the ring becomes divided into four quadrants, with the plus-plates above and below, and the minus-plates in front and in rear. Lemmrich designated these two types of arrangement as B and A, respectively. The accompanying copies of his diagrams (fig.1) make the distinction clear.

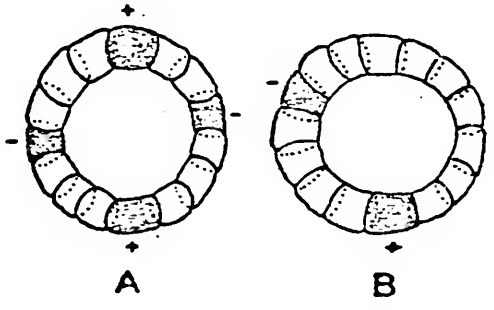

Fig. 1. Diagram showing the two principal types of sclerotic ring in birds. After Lemmrich, 1931.

Among reptiles, the sclerotic rings of the marine forms, ichthyosaurs, plesiosaurs, and mosasaurs, have long been known. In *Sphenodon* and the Lacertilia the arrangement is that of Lemmrich's type A, highly modified in some cases. A variety of archosaurs possess the structure, including the dinosaurs. Sclerotic rings have been recognized in *Plateosaurus* and *Diplodocus* (Sauropoda), *Struthiomimus* (Theropoda), *Saurolophus*, *Prosaurolophus*, and *"Trachodon"* (Ornithopoda), and *Centrosaurus* (Ceratopsia).

Brown (1912) was the first to describe the sclerotic ring of a hadrosaur. In his description of the skull of *Saurolophus osborni* he interpreted the ring as consisting of 13 plates, elongate-hexagonal in shape, and overlapping each other in a continuous, counter-clockwise (on the right side) series. Such an arrangement, if correct, would be unique. Later, when Brown observed sclerotic plates in the orbit of the horned dinosaur *"Monoclonius"* (*Centrosaurus*) *nasicornus* (1917), he restored the ring in the same arrangement that he had described for *Saurolophus*.

A much more normal arrangement of the sclerotic plates was described by Parks (1928) in the skull of the theropod *Struthiomimus samueli*. Parks observed that the ring "seemed to be composed of twenty plates arranged in four quadrants. The central upper and lower plates overlap the adjacent plates on each side; the central lateral plate on each side is correspondingly overlapped by both adjacent plates; the intermediate plates are in accord with this arrangement." It will be seen that the ring described by Parks belongs to Lemmrich's type A. The occurrence of type A sclerotic rings in the Hadrosauridae was shown by Edinger (1929, p. 193), who figured and briefly described this structure in the famous *"Trachodon annectens"* skeleton in the Senckenberg Museum. In this specimen the upper quadrants of the ring appear to contain more plates than the lower.

NEW MATERIAL

A skeleton of *Lambeosaurus lambei* Parks (=*Stephanosaurus marginatus* of Lambe's later writings) was collected in 1919 by a Royal Ontario Museum expedition under the direction of the late Professor W.A. Parks. The specimen (No.1218) was obtained from the upper Belly River beds (Oldman formation) on the south side of Red Deer river, in legal subdivision 3, section 4, township 21, range 11, west of 4th meridian. The site is quarry 3 of the Steveville map*. Preparation of this specimen was undertaken recently by G.E. Lindblad and when the skull (pl. I) was free of matrix, L. Sternberg, chief preparator, drew the writer's attention to the occurrence in the right orbit of a well-preserved, although partly displaced, sclerotic ring (pl. II).

As preserved, the posterior half of the ring is in place, whereas the anterior half has been displaced considerably. The posterior minus-plate is clearly recognizable, widely overlapped by the pointed ends of the two adjacent plates. These two overlapping plates are actually in contact at their adjacent ends. The existence of this minus-plate, so clearly demonstrated by the present specimen, is sufficient proof that the arrangement of the overlap is not serial, but is opposite in different parts of the ring.

Continuing upwards and forwards, clockwise, from the posterior minus-plate, each successive plate is seen to overlap widely the previous one. There are 3 of these plates, and the last, which is imperfect, is thought to be the upper plus-plate. In the lower posterior quadrant the overlap is in the opposite direction, and there are 4 plates present. That the last of these is the lower plus-plate is shown by the fact that it still overlaps the adjacent plate of the somewhat displaced antero-inferior quadrant. In this quadrant the plates are 3 in number, overlapping counterclockwise; the last of these is free at the upper end, due to displacement of the antero-superior quadrant,

* Dept. Mines, Geol. Surv. Canada, 1936.

but it is shallowly excavated at this end, as if to receive the overlap of the next plate. For this reason it is thought to be the anterior minus-plate. Not much can be determined about the antero-superior quadrant, which is displaced beneath the adjacent plates, but apparently the overlap is clockwise.

Individual plates have an elongate-hexagonal form, the pointed ends being in some cases irregular, in others, smoothly rounded. The external surface of each is shallowly concave from side to side, giving a faint trough-like character to the ring.

The restoration of the sclerotic ring of *Lambeosaurus*, which appears in figure 2, is doubtful in some particulars, but there seems to be no doubt that an arrangement of Lemmrich's type A is present. The postero-inferior quadrant is composed of 4 plates, and the antero-inferior and postero-superior apparently each of one less. It is usual in rings of type A for the number of plates per quadrant to vary. Those in the antero-superior quadrant cannot be determined, but this segment is restored as the counterpart of the opposite quadrant, with 4 plates.

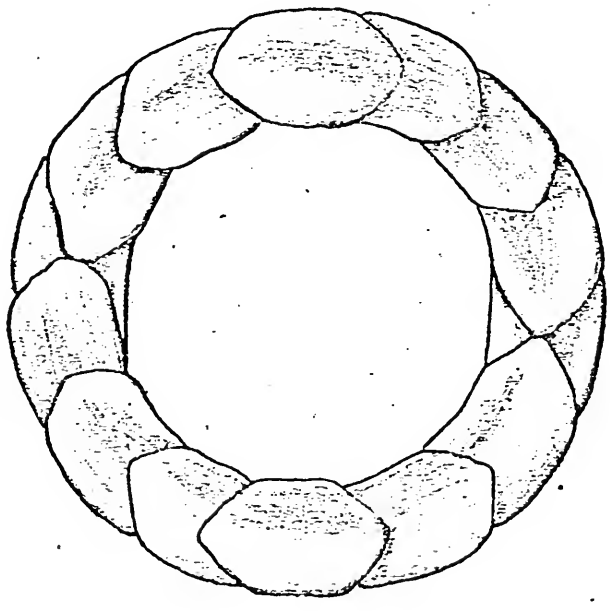

Fig. 2. *Lambeosaurus lambei*, restoration of right sclerotic ring; natural size.

The outside diameter of the perfect ring would be between 55 and 60 millimeters, and the inside diameter not more than 30 mm. This indicates a pupil of relatively small size, especially since the diameter of the orbit is over 30 mm. at its narrowest. A complete plate would measure about 22 mm. in length and 13 to 15 mm. in width.

Through the courtesy of Mr. C. M. Sternberg, the writer has had the opportunity of examining the sclerotic ring from a skull of *Saurolophus* preserved in the collection of the Geological Survey of Canada, Ottawa. On this specimen the presence of one minus- and one plus-plate is clearly demonstrable, but there has been some displacement, and the displaced plates lie in the piece of matrix removed from the front of the ring. If this displaced portion is the postero-inferior quadrant, as believed by Mr. Sternberg, the arrangement of the plates would be that of Lemmrich's type B. The somewhat less probable interpretation, that the antero-superior quadrant is the displaced one, would permit interpretation as type A. In any case, it is clear that the overlap of sclerotic plates in this specimen of *Saurolophus* is not serial, but is interrupted by the presence of at least one doubly overlapped (minus-) plate. and one doubly overlapping (plus-) plate.

CONCLUSIONS

In spite of the very definite statement by Brown that the sclerotic plates of *Saurolophus* overlap serially, it seems probable that the ring in hadrosaurs is similar to that in birds, *Sphenodon*, lizards, and other dinosaurs, in having one or more segments in which the plates overlap in opposite direction to those in the other segment or segments. In *Lambeosaurus* and *Thespesius* we find the arrangement to be similar to the type A ring of birds, i.e., divided into 4 quadrants, with a doubly overlapping (plus-) plate above and below, and a doubly overlapped (minus-) plate in front and behind. A specimen of the ring in *Saurolophus* suggests the type B arrangement of birds, with plus-plate at one end and minus-plate at the other.

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Parks, W.A., 1928; Univ. Toronto Studies, No.26, p.19, pl.2.

EXPLANATION OF PLATES

Plate 1. *Lambeosaurus lambei* Parks, right side of skull, Royal Ontario Museum of Palaeontology, No.1218, showing sclerotic ring in place; X 1/6.

Plate 2. The same, showing details of right sclerotic ring; X 1.

PLATE I
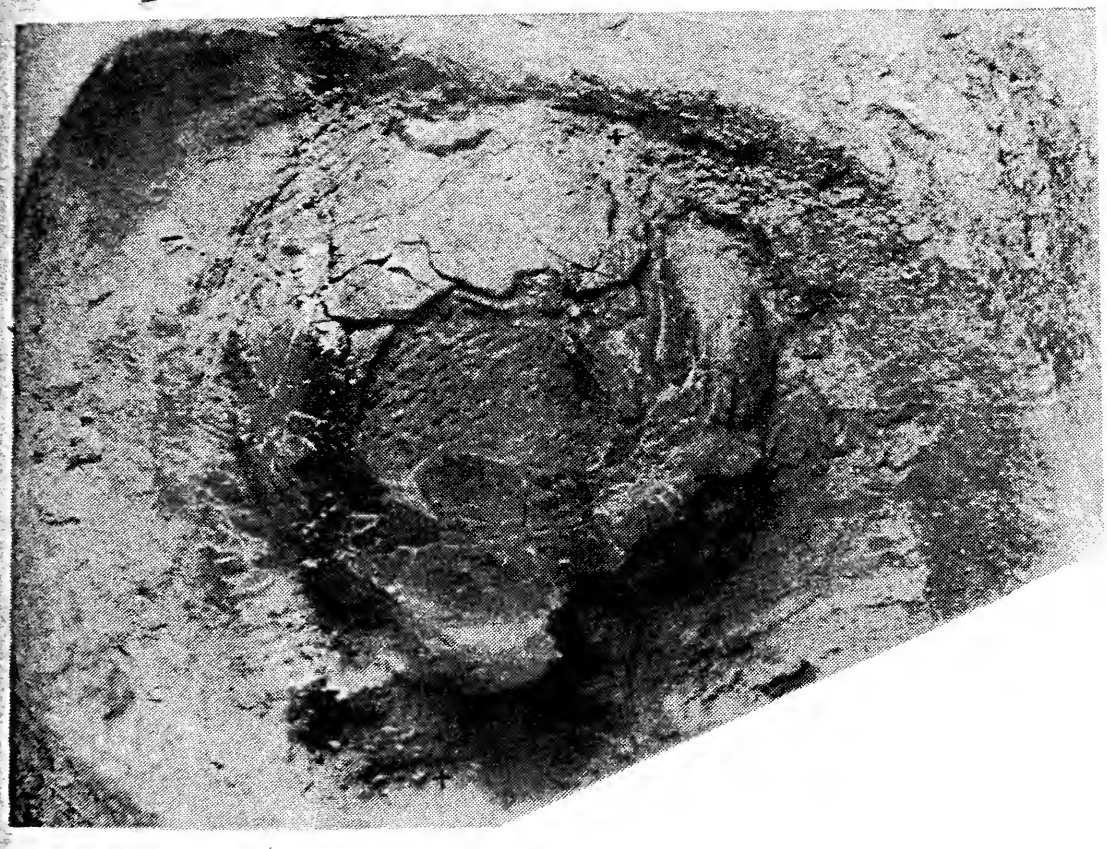
PLATE II